CLAIMS

WE CLAIM:

1. A safety industrial controller receiving signals from electrical sensors on a safety process and providing signals to electrical actuators on the safety process, the safety industrial controller comprising:

input circuits receiving input signals from sensors and transmitting them to logic circuitry before a first worst-case delay;

logic circuitry receiving the input signals from the input circuits to create at least one output signal based on the input signals and transmitted to an output circuit before a second worst case delay; and

output circuit receiving the output signal from the logic circuitry to output the output signal to an actuator before a third worst case delay only if the time elapsed since the input circuits received at least one of the input signals is less than a predetermined time limit, the predetermined time limit being less than the sum of the first, second, and third worst case delays, and otherwise the output circuit entering a predetermined safety state.

2. The safety industrial control of claim 1:

wherein the input circuits repeatedly transmit the input signals to the logic circuitry at a predetermined repetition period less than the predetermined time period and ;

wherein the logic circuitry creates the output signal at a repetition rate triggered by receipt of the input signals.

3. The safety industrial control of claim 1:

wherein the input circuitry includes a time stamp means creating a time stamp indicating a time corresponding to the receiving of the input signals by the input circuits;

wherein the logic circuitry includes means for associating the output signal with one time stamp of the input signals so received; and

wherein the output circuitry includes means for providing an output signal to an actuator only when the output signal arrives at the output circuit before a time equal to a time stamp of a previous output signal plus a predetermined time limit.

4. The safety industrial controller of claim 3 wherein the input signals are redundant input signals and the time stamping means creates the time stamp when the redundant input signals have coincidence.

5. The safety industrial control of claim 3:

wherein the input circuits repeatedly transmit the input signals to the logic circuitry at a predetermined repetition period less than the predetermined time period and ;

wherein the logic circuitry creates the output signal at a repetition rate triggered by receipt of the input signals.

6. The safety industrial control of claim 3 wherein the means for associating associates the earliest time stamp of the input signals with the output signal.

7. The safety industrial controller of claim 3 wherein means for associating follows a user defined time stamp function indicating which of the time stamps of the input signal is associated with the output signal.

8. The safety industrial controller of claim 3 wherein the input and output circuits have synchronized clocks.

9. The safety industrial controller of claim 3 wherein the input and output circuits have asynchronous clocks and wherein the input circuit provides a value to the output circuit indicating an offset between the clocks of the input and output circuits and wherein the predetermined time limit is the sum of a maximum allowable propagation delay plus the offset value minus an uncertainty in the offset value.

10. The safety industrial controller of claim 1 wherein the first worst case delay includes a time to transmit the input signals on an electrical medium connecting the input circuits to the logic circuit.

11. The safety industrial controller of claim 1 wherein the input circuit includes a filter and wherein the first worst-case delay includes a filter rise time.

12. The safety industrial controller of claim 1 wherein the second worst case delay includes a time to transmit the output signals on an electrical medium connecting the logic circuit to the output circuit.

13. The safety industrial controller of claim 1 wherein the safety state provides a safety output value determined by a user.

14. The safety industrial controller of claim 1 wherein the input circuits transmit the input signals to logic circuitry after a first average delay and the logic circuitry transmits the output signals to the output circuit after a second average delay, and the output circuit transmits the output signal to an actuator after a third average delay; and

wherein the predetermined time limit is greater than a sum of the first, second, and third average delays.

15. The safety industrial controller of claim 1 wherein the output circuit is implemented with a processor executing a stored program.

16. The safety industrial controller of claim 1 wherein the output circuit is implemented with dedicated circuitry.

17. A method of operating a safety industrial controller receiving input signals from electrical sensors on a safety process at input circuits and transmitting the input signals to logic circuits to produce output signals transmitted in turn to output circuits and then to electrical actuators on the safety process, the method comprising the steps of::

at the input circuitry, transmitting received input signals to logic circuitry before a first worst-case delay;

at the logic circuitry, creating at least one output signal based on the input signals and transmitting the output signals from the logic circuitry to an output circuit before a second worst case delay; and

at the output circuitry, outputting the output signal to an actuator before a third worst case delay only if the time elapsed since the input circuits received at least one of the input signals is less than a predetermined time limit, the predetermined time limit being less than the sum of the first, second and third worst case delays, and otherwise the output circuit entering a predetermined safety state.

18. The method of claim 17 including the steps of:

the input circuits repeatedly transmitting the input signals to the logic circuitry at a predetermined repetition period less than the predetermined time period and;

the logic circuitry creating the output signal at a repetition rate triggered by receipt of the input signals.

19. The method of claim 17 including the steps of:

creating a time stamp indicating a time corresponding to the receiving of the input signals by the input circuits;

associating the output signal with one time stamp of the input signals so received; and

providing an output signal to an actuator only when the output signal arrives at the output circuit before a time equal to a time stamp associated with a previous output signal plus the predetermined time limit.

20. The method of claim 17 wherein the input signals are redundant input signals and the time stamp is when the redundant input signals have coincidence.

21. The safety industrial controller of claim 19 wherein the output signals are provided to an actuator only when the output signal arrives at the output circuit before a time equal to a time stamp associated with a previous output signal plus a

first predetermined time limit and the output signal arrives at the output circuit before a time equal to a time of receipt of an immediately preceding output signal plus a second predetermined time limit.

22. The safety industrial controller of claim 19 and the time stamp of the input signals associated with the output signal is the earliest time stamp of the input signals so received.

23. The safety industrial controller of claim 19 wherein the time stamp associated with the output signal follows a user defined time stamp function indicating which of the time stamps of the input signal is forwarded by the output signal.

24. The method of claim 19 wherein the input and output circuits have synchronized clocks.

25. The method of claim 19 wherein the input and output circuits have asynchronous clocks and wherein the input circuit provides a value to the output circuit indicating an offset between the clocks of the input and output circuits and wherein the predetermined time limit is the sum of a maximum allowable propagation delay plus the offset value minus an uncertainty in the offset value.

26. The method of claim 17 wherein the first worst-case delay includes a time to transmit the input signals on an electrical channel connecting the input circuits to the logic circuit.

27. The method of claim 17 wherein input circuit includes a filter and wherein the first worst-case delay includes a filter rise time.

28. The method of claim 17 wherein the second worst-case delay includes a time to transmit the output signals on an electrical channel connecting the logic circuit to the output circuit.

29. The method of claim 17 wherein the safety state is an output determined by a user.

30. The method of claim 17 wherein the input circuits transmit the input signals to logic circuitry after a first average delay and the logic circuitry transmits the output signals to the output circuit after a second average delay, and the output circuit transmits the output signal to an actuator after a third average delay;

wherein the predetermined time limit is greater than a sum of the first, second, and third average delays.